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SUGGESTIONS AND COMMENTS ON BANANA GROWING AND SOME RELATED SUBJECTS

TELA, HONDURAS, DIVISION

B. T. GALLOWAY

JULY 6, 1927

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Book number P698

PRESENTED BY

Dr.B.T.Galloway

Tela, Honduras. May 2, 1927.

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Mr. R. K. Thomas, Manager, Tela Railroad Company, Tela, Honduras.

Dear Mr. Thomas:

Before leaving Tela I want to thank you and through you the members of your staff for the many courtesies shown me. It has been a pleasure to note the keen way in which almost every conceivable phase of banana culture is discussed, argued, dissected and weighed by all your workers. This shows a fine spirit and a splendid morale. I have never experienced anything else like it.

When I return to Washington I shall assemble the data gathered and, after discussing some of the more pressing and important problems with our specialists, will submit a memorandum of suggestions. I hope by this means to bring to bear on some of the problems the wisdom and judgment of our specialists and experts. Now that I have seen the work of banana production and have gained direct knowledge of some of the problems, I hope in the future to be of assistance in effecting close contacts between workers here and specialists in the Department at Washington.

It has been my good fortune to have served the Department for forty years and I know from experience that my colleagues will always be glad to aid you when problems are presented in a specific and concrete way. After all, we regard the work of the United Fruit Company in the tropics as a great American enterprise; therefore, worthy of our full cooperation and support.

Sincerely yours,

(Signed) B. T. Galloway

cc Mr. R. H. Goodell

Mr. A. J. Chute

Mr. Wilson Popence

Mr. R. R. Thomas, Manager, Tela Hailroad Company, Tela, Hondures.

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July 6, 1927.

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cc Mr. Geo. P. Chittenden

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Mr. R. K. Thomas, Manager, Tela Reilroad Co., Tela, Hondaras.

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B. T. Galloway, Flant Pathologist.

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TELA, HONDURAS, DIVISION

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Through the courtesy of the United Fruit Company, an opportunity was afforded for visiting the banana plantations of the Tela, Honduras, Division, with an incidental trip to Guatemala, including Guatemala City, Antigua and vicinity, and the banana plantations near Quirigua. We arrived at Tela April 16, 1927 and left on May 9. We arrived at Puerto Barrios May 10 and spent five days in Guatemala, sailing for home May 15.

INTRODUCING AND TESTING NEW AND PROMISING CROPS

It is gratifying to note the progress made in systematic plant introduction and testing at the Lancetilla Station near Tela. Considering the short time this work has been under way, the advances have been rapid. The location at Lancetilla seems almost ideal for the kind of work involved. The growth of many crops like bamboos, mangoes, avocados, lychees, and citrus compares favorably with what we have seen in other parts of the world.

Aside from the direct benefit of such work, too much emphasis can not be placed on its indirect or potential value. A crop that shows little promise at the outset may eventually prove of great value. This has been proved time after time in our own work in the Department of Agriculture. It would appear, therefore, that a broad program, looking toward the gradual development of this type of work so as to make it applicable to all the Central American divisions, is well worthy of consideration.

Plant Introduction and testing of new and promising crops is one of the oldest of horticultural practices, but its value can be greatly enhanced by systematic studies of the needs involved, followed by careful testing and consideration of the broader economic questions at issue. An organization

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Flant Introduction and testing of new and promising crops is one of the oldest of horticultural practices, but its value can be greatly enhanced by systematic studies of the needs involved, followed by careful testing and consideration of the broader economic questions at issue. An organization such as the United Fruit Company must necessarily look a long way ahead in shaping its plans and policies for future growth and permanent remunerative returns. The economics of agriculture are rapidly changing all over the world. The increasing cost and instability of labor, the rapid decrease of virgin lands, the exhaustion of soils, and the cumulative effects of diseases and pests, all conspire to make it well worth while to plan a long way shood for meeting the difficulties bound to arise. Plant introduction may not provide a substitute crop of the economic importance of the banana, but it may materially aid in stabilizing the banana industry and the organization around which the industry is built, through the utilization of land no longer available for bananas and which, for many reasons, can not be abandoned to the jungle. And then there is the important question of securing crops which may be fitted into plans looking toward the continued enrichment and improvement of the soil where bananas are the major crop and where indications point to their maintaining this status for a long time. In the Oriental tropics the need of maintaining soil fertility and correcting unfavorable conditions through cover crops and green manures has been recognised and steps are being taken to meet the situation. As we shall point out later, cover crops may become an important factorain disease control.

SPECIFIC SUGGESTIONS REGARDING SOME NEW CROPS

warnish trade. The principal source of this material is China. The importation of oil into the United States amounts to about \$10,000,000 a year. There is no tariff on the oil. At the beginning of 1927 indications pointed to a shortage in the wood-oil supply from China. This was further emphasized by

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the February shipmonts. Despite disturbed conditions, however, reports show that for the first four worths of 1937, there were meanly 20,000,000 pounds of wood oil imported, or about the same assumt as last year. The prices have varied from 20 to 28 cents per pound. The industry is not an organized one in China, the nuts being gathered and assembled in community centers where the oil is extracted. Florida is making headway in the planting of wood-oil trees, something over 2,000 acres being out at this time. The tree grown in Florida is known as Alcurites fordii. This does not seem to do well at Tela. Mr. Popenes's experiments show that A. montena is more promising. In view of the situation in China and the increasing depand for the product, this would seem like an industry worthy of encouragement. One of the pressing and immediate needs is the assurance of a future supply of montane seed for propagating purposes. In all liklihood, the supply of seed from China for the next few years will be very limited. The nethods of vegetative propagation being worked out by Mr. Butler are likely to be of much importance leverty Movember The perfect for 1904 persons in the Skale in

division offer some encouragement. With labor conditions as they exist in Mondaras and with a rather long, cool and wet winter, it is questionable whether Heves can be grown satisfactorily here as in other parts of the tropies. It is well worth while, however, to continue investigations with the plant so as to get all practical information as to its habits, differences in saedling types, behavior under different soils and environment, and also for the purpose of securing plant material that might be utilized in other more tropical divisions. The crucial test of the project will come several years hence, when tapping becomes necessary. Two species of rubber vine,

egger angles and the relation to the first field of the file of the contract o abaroc 000,000,000,00 plane sers eres and von sold surif off the cast of sod oil imported, or about the same assumt as last year. The prioce have sailed from 20 to 28 contains your cound. The industry is not an organized one in this, the miles being gathered and described in community centers where the book to animale sat at washase animan at abivoff . bactanine at lie ont ai awerg eest ed? Temif Shirt de two mine avers Offic ave pardue on peend Mr. Popraette aspiritualita obsertitualita in mendena in morte promiser. Es vitus I the mitter that it told and the same decimal for the product, this nest in the training of encouragement. One of the proving med from periodic to proper world in the receivable of the lower while has was artiful moon from to refrom set plocatifits the at the equal parties -re or will was to in rights off which is not of LH, many bullets own and the reference we say the thought over reliber will be for before pulled ask to a 1 2 1

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more tropical divinions. The crucial test of the justect will come several

years hence, when tapping becomes necessory. Two species of rubber vine,

Cryptostegia grandiflora and C. madagascariensis, offer encouraging potential value as rubber producers. These plants are being tested in southern Florida and do fairly well there, although the winters are rather severe on them.

There is good evidence that the Cryptostegias are well adapted to conditions in the Tela division. Both species lend themselves well to labor conditions and other factors existing at Tela. Machete harvesting, continuous cutting from the same roots from year to year, utilization of existing railways and rolling stock for bringing the raw material to a central place for extraction, and tank shipments of the latex to the States for refinement are some of the possibilities. The Cryptostegia rubber is said to be of fair quality and it has been found that it can be extracted by mechanical processes similar to those now in commercial use for extracting rubber from the Mexican Guayule plant, Parthenium argentes.

MANGOES, AVOCADOS AND LYCHEES - There would seem to be an opening for the culture of these fruits in the Division, especially at the western end near Progreso. The market for good mangoes in the State is growing, and Florida and nearby countries are not meeting the situation. The question of fruit flies and other pests must always be kept in mind, but if it can be shown that the districts where the fruits are grown are free from these insects, the entrance of the fruits would not, in all liklihood be barred. In other words, the development of any industries with fruits of this nature must have back of it the assurance of insect control and the reduction to a minimum of the liklihood of introducing dangerous pests into the United States. The lychee fruit offers less risk as an insect carrier, and it is believed it would find a ready market here, as it would not compete with other fruits. All the lychee trees seen around the division were remarkably vigorous and

Envisoring examination and Comminguishers in the consequence of the value as reform products. These plants are being tested in each on the said to fairly said there, although the sinters are rether severy on the said to fairly said there, although the sinters are said adapted to said them. There is to deposit the said themselves well to labor conditions and the fold division. Doth species tend themselves well to labor conditions and other fold division said that the same species are the said to be severally, continues said for the said the said that adjusted to the said to a contral place for collection and the said the said that adjusted to the deposit of the deposit of the deposited by said to said the said the said that the said the said the said the said that the said the

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healthy, but they had set no fruit. This difficulty might be overcome by ringing or perhaps by other methods. The subject is one worthy of study as the lychee lends itself to long-distance shipments and would make quite a "talking card" if placed on our fruit stands. The avocado seems questionable as an industry unless ways could be found for preserving it.

BAMBOO - The whole of the Tela division, and especially the lands at the eastern end, are well adapted to bamboo culture. There is a good market at present for many kinds of bamboo poles and canes. The Orient supplies this market. The details of this matter have been discussed with Mr. Popence.

COVER CROP SEED GROWING - The ease with which some important cover crops like Croteleries, cow peas, and soy beens grow at Lancetilla suggests the possibility of utilizing outlying lands for seed production. Cow peaseed has been bringing from \$5.00 to \$8.00 per bushel for several years, and the Crotaleries are attracting much attention. Questions of seasonal adaptability, methods of harvesting, storing and evercoming insect peats would all need to have careful consideration. The marketing situation would also need study before serious embarkation on projects such as the one here considered. Further discussion of cover crops is given under the wilt disease heading.

BANANA IMPROVEMENT THROUGH BUD SELECTION

The bud selection work with the Gros Michel banana, inaugurated something over a year ago at Tela by Mr. A. D. Shanel, of the U. S. Dapartment of Agriculture, and now being carried forward by Mr. Wilson Popenoe, has progressed sufficiently to indicate the complexities of such an undertaking. Improvement of a plant like the banana through bud selection is a unique undertaking. Much work of this nature has been earried on with other plants. In fact, bud selection, either conscious or unconscious, is a practice long fol-

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lowed by horticulturists growing both ornamental and fruit crops. The plants involved, however, with comparatively few exceptions, have been of a different type from the banana, but that should not detract from interest in the work or discourage undertakings looking toward improvement of the crop. Whatever the direct outcome may be of bud selection with the banana, I am confident that such studies, carefully planned and carried out, will well repay any reasonable effort in time and money through bringing about a better and more accurate knowledge of the life history and habits of the plant. This has been the history of all such work whenever and wherever undertaken. What may be called the by-products resulting from the work will well repay all reasonable efforts and expense in carrying it through.

There is no questioning the fact that Mr. Shamel's bud selection work with citrus fruits in California has been of major importance to the industry. To even attempt to enumerate the direct and indirect benefits would be beyond the scope of this memorandum. Whether such a feat can be accomplished with other crops remains to be determined, but it is certain that benefits will accrue, for the fundamental idea is to gain knowledge of the habits, response to environment and life functions of the plant to the end of increasing the quantity and quality of the product at decreased cost. We must not be understood as intimating that such work as Mr. Shamel has done and is doing can be reduced to mathematical formulae, -blue-printed as it were- then passed on to bthers for execution. Mr. Shamel is wholly original in this respect. Certain of his methods can be formulated, followed and made worth while, as already pointed out. Our suggestion as to this work is that it be regarded as a relatively long-time proposition: that it be kept largely in the hands of those who are trained in research and who can interpret results through the background of knowledge of plants and plant reactions to environment.

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Mr. Shamel, in his recommendations setting forth proper procedure, has stressed the need of time and care in all the preliminary stages in developing the performance records. To this end two performance record plats are under observation, both in the western end of the Tela division. We make the suggestion that as soon as practicable other plats be brought into this work. This will reduce the hazards from blow-downs, will widen the range of environmental reactions and will begin to bring together valuable practical data as by-products of the selection work. Mr. Shamel, in his citrus improvement work, has carried from 8 to 10 widely scattered plats for ten or twelve years, something over 6,000 trees being involved. We recognize that a limiting factor here is the time and labor involved in making the great number of necessary measurements, weighings, etc. With this in mind, we believe it well worth while to insugurate an additional method of systematic selection based on what Mr. Shamel calls "estimates" rather than detailed measurements and records. We may designate this as systematic mass selection looking to the improvement of all new banana plantings. Mass selection would involve (1) e definition and an agreement as to type, the same to be determined by the combined judgment of a seeected small group of experienced banana men; (2) adherence to the type so far as practicable in future plantings and replantings. It may be necessary to develop a special small group of men for the purpose of carrying through this mass selection work. There is scarcely an intensive plant industry anywhere in the world involving vegetative propagation where some form of mass selection is not consciously or unconsciously followed. It has been developed in perhaps its highest form by the great cut-flower industries of the United States, involving roses, carnations, violets and such things, also in the improvement of thousands of ornamentals

-ob at assert washing edd the ut area bus smit lo been soft beareads and loping the performence records. To this end two performence record plats spire of authorized and the less produce of places and arrange pales. The the suggestion that as soon as practicable other plats be brought into this ork. This will reduce the hazards from blos-downs, will widen the reage of . Ironwental reactions and will begin to bring together valuable practical. data as by-products of the selection work. Mr. Sasmel, in his citrus improvesent work, has cerried from 8 to 10 midely sectioned place for ten or twelve rurs, mething over 6,000 trees being involved. We recognise that a limitto reduce the time and labor involved in making the great number of magnesser contervers to, religious, atc. Hits etts in citi, se believe in religion in militari in religions with relative to the control of some control of a restrict of the control of the one ajmarauresen ballajab ment redist "estimetes" alles Lemand . Til Jan r our m. We may designate this as systematic mass selection looking to the (I) when I are made and resident and the last of the l contined judgment of a salected amall group of emperienced beneat (2) - III or in this is accurated in the distance of the contract of the contract of ings. It may be mecessary to develop a special small group of wear for the programme of correct through this same with the correction of the solution - Carrier or a visit for the first of the second follows: It has been seeinged as property the beginning and suit if the great amplification among privilegal project letter of the evidence wave Column this party to electronic to which required at pale at pale at the first feet with the

and with many fruits and vegetables. The white potato and sweet potato are common examples in the vegetable group.

Mass selection, properly organized and carried through, should (1) increase production; (2) improve quality; (3) develop greater vigor, and (4) possibly make for greater resistance to disease, although we believe selection for disease resistance should be considered separately. To carry through amount outs of he at which such a plan successfully would involve the assembling and growing of the selected material in nurseries and the utilization of these nurseries in was the almey on his han furnishing plants for field use. A nursery controlled by the California Fruit Growers' Exchange has distributed more than three million selected buds for propagating purposes in the past five years. Why not a nursery, conducted under strict sanitary control, growing and furnishing to the division mass selected banana bits whose history is known? We recognize that there are details to be worked out in any such plan, but none of these would appear to involve insurmountable difficulties.

GRADING BANASAS

requirementary will be

The actual state of growth or ripening of a banana can not be accurately determined by external characters or appearance. This is true of other fruits, particularly the apple. Internal conditions or what may be called the physiological state vary with the season and with the conditions under which the fruit is grown. Recently there has come into use an instrument devised by a member of the Department's staff for measuring the state of ripeness of fruit through pressure tests. We have suggested this instrument for banana work and have sent one of them, together with a detailed account of the methods to be followed to Mr. Wilson Popence.

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out vien may fault and vegetables. The white potate and sweet potate are

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- iscreens prometions (2) in revergelity; (3) armite than the presentation of these particles. In these particles are considered separately. To curry through the first successfully would involve the assembling and growing of the sleeped material in nurseries and the utilization of these nurseries in farmining plants for field assembling and proving of the farmining plants for field assembling the distribution of these nursers in the distributions are related to the distribution and the strict satisfactor in the past five part. It was a nurser, contacted address that is a strict satisfactor is to all these would appear to tails to be worked out in any such plan, but none of these would appear to invest to be worked out in any such plan, but none of these would appear to

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SOIL TILLAGE

the second of th In going about among the banana farms we found keen interest being free lack of welfarms levelyness of the real places places manifested in the question of soil tillage. Naturally questions like this will arise as the need for more intensive culture develops. Sweeping the whole tillage matter into a more or less tentative generalization, it would entil detailers by compilificating event or period of the seem, on general principles, that on the best banana lands tillage will prove A total car and could succeed be read from the age of early to profitable and advantageous in a number of ways when simed primarily at weed control through shallow plowing or, preferably, disking. Doctor Bennett of the Bureau of Soils gives the above as his judgment after long studies of company that is not shown that we plate the big will seek now the tropical soils in Cuba and Central America. This opinion is backed by a mass contider to over modinations is grath arms or support an Alfalof experimental evidence which has materially altered the viewpoint of scien-\$**.** 域: tific workers in the last eight or ten years. There may be, and likely are, tillage mitur drottestion sould appear to be telephil, but the some exceptions as where, for example, the presence of large amounts of colmaking to in Calleted and Un your hi broad/ore stated loids may cause deep cracking. Inasmuch as the consensus of opinion now appears to be that the loss of soil moisture is largely through vaporization. the futility of deep tillage as a means of moisture conservation will be and Enteresting and for-mountain problems . Rents will not permit of detellant understood. In this connection it might be well to quote one of our irrigat-LACTURALACE. SER C ion engineers:

"Soil moisture is that form of moisture held in the soil by capillarity and available for plant use. The popular conception is that this moisture may move around in the soil quite freely and somewhat rapidly. Especially is it thought to move upward to the soil surface freely and from considerable distances. Experimental work by the Division of Irrigetion Investigations upon the capillary movement of soil moisture from a wet or damp soil to a dry soil has demonstrated that the popular idea is erroneous. This work showed that the lateral movement of soil moisture by capillarity during a period of 30ndays through a distance of 6 inches in a loam soil was less than half enough to support an alfalfa crep. Euring the same period of time, moisture did not move from the wet soil 18 inches laterally into the dry soil. Barley plants, the roots of which were confined within a space 6 inches square,

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In wing these teach tenders in the best through the first that the first of mentiferted in the question of soil tiliage, Asturelly entraired like Ulia will arise as the need for more intentive culture divelogs. Browning the whole tills a matter into a nore or less teriative goneralization, is would areas, in general principle, that on the bear hand and tilling will prove term is afterested bearing and expert to andmore a at appropriate has offerittere control through shallow ploring or, preferably, dicking. Doctor Canactr of to salbuda and totte ducer but ald as avoid add sevin salet to suressi odd Grapical soils in Cube and Cantral Ingrion. This opinion in backed by a nare of experimental evidence which has materially altered the view pint of secontifue workers in the last witht or ton years. There are be three ore some exce tions as where, for example, the presence of large emounts of col-Loids to cause deep cracking. Inasmuch as the consensus of opinion now aprears to be that the loss of noil meighter is layed to through vaporiselies. the fuellity of deem tillers as a massa of moisture comportation all the wederstood. In this commection it wight be well to sucke our of our irrigit.

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within a body of wet soil, thrived for about 50 days, then began to wilt, and within two weeks more were all but dead for lack of moisture. Analysis of the soil showed plenty of moisture at 2 inches from the roots.

"The upward movement of soil moisture is not so rapid or extensive as the lateral movement. Numerous experiments gave results tending to show that the downward movement of soil moisture by capillarity over a period of thirty days was approximately one and three-fourths times as far, and that twice as much moisture moved down as up. Gravity is working all the time upon soil moisture, tending to pull it down below the plant roots. The experiments have demonstrated that capillary moisture is influenced greatly by gravity and that soil moisture, once below the root zone, is all but entirely lost in so far as nourishing plants is concerned. Numerous tests have shown that capillarity will not move it through even a few inches rapidly enough or in sufficient quantity to grow and mature a grain crop or support an alfalfa hay crop." (Bamuel Fortier, Yearbook of the Department of Agriculture: 19201) W WW.

Tillage after irrigation would appear to be helpful, but the practices to be followed are the same as heretofore stated.

IRRIGATION

The irrigation projects in the Progresso district open up some interesting and far-reaching problems. Space will not permit of detailed discussion. We can touch only a few of the high lights which have developed as a result of our conference with experts here. Following are some of the outstanding points:

1. Irrigation such as is being carried on in the Progresso district will doubtless need to be accompanied by a rational system of fertilization, otherwise soil exhaustion will follow. The quick jump in yields after the application of water points to a drain on soil fertility that probably could not be maintained long without outside aid.

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The irrigation englashed in the Progress of interior special of debiled one interesting and for-reaching problems. These will not possible of debiled discussion. To sum touch only a for of the hips light safethers developed as a result of our cultivates with argument here. Following are resconfined on our cuttons.

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frequency consisted with wind with fallow. The prior jump in piets of a consistency of

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- 2. Irrigation may result in an annual rise in the water level (Farm 11) during the rainy season with resultant injury to the banana roots. To offset this, means must be provided for carrying off the excess water through some more or less simple system of ditching.
- 3. Irrigation, followed by improper tillage, may result in hard pan. This point has been covered under soil tillage.
- 4. The mechanical and engineering equipment for pumping water from the river appears to be worthy of study. Details of investigation in the States, involving more or less mobile pumping plants without costly instalation, will be sent to Mr. E. F. Speh.

UTILIZATION OF FRIABLE AND NON-FRIABLE CLAY SOILS

Doctor Bennett of the Bureau of Soils has made a special study of the friable and non-friable clay soils of the tropics. His complete technical paper will be found in Soil Science, vol. 21, pp. 349-376. No suggestions are made there as to utilization of these soils. He has suggested to us that on the friable clays, where drying out is a factor and where there is good drainage, plantings might be done in shallow tranches as for sugar cane in Cuba. The tranches may be 18 inches deep with sloping sides, the top being 2 to 3 feet across. The plants are started in the bottom of the tranches, thus insuring deep rooting and freedom from drought injury. The non-friable clay soils are more common in the Tela division and offer some encouragement for banana culture. Acration, drainage and permeability are important questions here.

Doctor Bennett suggests trisls with the so-called "grand bank" method in utilizing such soils. The "bank" as used in Cuba is about 20 feet wide, 18 inches high at the center, and slightly sloping to the drainage depression so as to insure quick removal of surplus rain water. This system

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Postor Newert of the Bureau of Soils has made a special study of the Policie. His complete beckuical with the Policie of the Propiets. His complete beckuical with the food in Soil Stieras, vol. 21, pp. 349-376. We suggestions are rain there as to willistian of those soils. He has surgested to us that on the color of the stierast of the second of the second of the stierast of the second of

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would give an elevated bed so made as to enhance aeration and drainage. Mr.

Popence already has the matter under investigation, based, I believe, on studies in Cuba. Doctor Bennett has recently made a detailed study of the soils of Cuba and his manuscript is now in the hands of Dr. W. A. Orton.

THE BANANA WILT PROBLEM

in the state of the second I have left this subject for the last (1) because, as a pathologist, it makes the greatest appeal to me, and (2) for the reason that it is the outthe Case Describing, and Hall they work your party and before an about the standing problem of banana culture in Central America at the present time. marked by Mrs. Provider his executable of any conjective as a suggest residue, here Those who may read this memorandum are familiar with the painstaking investiaccordance with more discover election to headen with two closes to exhibit to be gations of the disease carried on during the past ten years, largely under the auspices of the United Fruit Company. An analysis of the situation, therefore, Surgery Control of the Control of th is not required. The immediate question is what, in the light of all that has continue there were be exhabited to this a reject, but such exhaust out to been done, can be suggested as promising fields for further study. Without STATE OF PERSONS ASSESSED. undue argument, we submit the following suggestions:

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1. That despite the lack of definite results in selecting Gros eligations between some discussion because on the and have Michel for disease resistance and despite the difficulties involved in bud and the Property County-Associated with the Well's appears upon before selecting any kind of monocotyledenous plant, renewed attention be given to this matter. The principal reasons for this suggestion are twofold; (a) bement exactly the contribution of the profession of the contribution of the contributio cause the Gros Michel banana does tend to show a variation or an apparent About a credit being proved to be habited publication and ability an eastern prints below variation in disease resistance, and (b) for the reason that in a long list The last feether synthese. Do need to you the problem and no professe are to of similar Fusarium soil diseases, such as flax, tomato, cow pea, cotton and AND CASE OF THE PROPERTY OF THE PARTY OF THE cabbage wilts, selection has proved successful in developing resistant strains. effects to FormTake and published effect a grajest involving This matter of selection, for disease resistance, seems of such paramount imcontinuing the state of the particular and the court of the second second portance that I would give it the status of a major project and put one or loan more on the part of a wall-instead such man, a plant stratelected and a better two good men upon it, the men to be trained horticulturists or gardenpathologist. I sale so then that I'v sealed her smullely results that will ers rather than pathologists. As a part of this project I would suggest that ballacingly place which may easi one gut be done in Potago burner are the Lacatan banana (Bungalan of the Philippines), known to be resistant, be

would giv at the very bed so need to comment the based, I believe, on the corner already is the need of the soils of the made a detailed study of the soils of the made and for all in manorists and the hands of Dr. W. A. Orton.

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i. That despite the lack of definite results in selecting Gross allowed for discuss resistance and despite the difficulties involved in bud selecting any line of approach plant, rescall situation to give to the selection are twofold; (a) because the despite that any and does tend to show a variation or an apparent variation is allowed resistance, and (b) for the reason that in a long list of similar luminium coll is once, and (b) for the reason that in a long list of similar luminium coll is once, and as flax, tomate, cow pea, cotten and collection wilts, calcoling the second in developing resistant strains.

This site of relacities the trace of this project I would suggest that the reason of this project I would suggest that the lack of the Philippines), known to be resistant, be

included in the selection work, the object being to develop a type bearing fruit characteristics as near as practicable like the fruit of Gros Michel. On theoretical grounds it ought to be less difficult to develop desired fruit characters than resistance to disease. To repeat, selection offers the most promising direct method of meeting the wilt disease problem and deserves the attention of the best talent that can be secured in pushing the matter to a conclusion.

- 2. That the breeding and hybridization work now being conducted in Panama by Mr. Permar be encouraged and supported as a major project, because experience with many diseases similar to bename wilt has shown breeding to be of great importance, especially when combined with systematic intelligent introduction and testing of new species, varieties, forms and strains. Of necessity, there must be selection in this project, but such selection would be applied to further improvement of hybrids or new forms secured by breeding. This will necessarily be a long-time project.
- and the fungus found associated with the wilt disease are extremely complex, and those relations are, no doubt, profoundly affected by the soil and its many complexities. As evidence of this, the application of P.H. tests is cited. This has proved a valuable indicator and will, no doubt, prove helpful in further studies. So complex are the problems and so pressing are the needs for an early solution of some of them that it would seem the part of wisdon to formulate and put into effect a project involving physico-biochemical, physiological and pathological work. This would mean coordinated team work on the part of a well-trained soil man, a plant physiologist and a pathologist. I take it that what is wanted are conclusive results that will definitely show what can and can not be done in future banana production under

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conditions as they exist in most of the Central American divisions. I believe the way to get these results with the least expenditure of time and
money is by a combined attack on the problems which involve those of the soil,
the host and the fungus. We know that many Fusarium diseases are affected by
soil temperatures. In fact soil temperature appears to be a limiting factor
in certain serious wilt diseases. As pathologists, we are prone to overlook
the effect of soil temperature on the physiological functions of the host and
the bio-chemical activities in the soil. All are intimately interrelated and
should be studied together.

As a working hypothesis, we may assume that <u>Fusarium cubense</u> is a facultative parasite, that it does not enter the banana plant unless and until the root hairs, or rather the protoplasmic contents of the root hairs, have been subjected to some outside detrimental influence not necessarily measurable by P.H. tests. The fungus itself, when invigorated by physic and biochemical activities or changes in the soil, may be one of the agents in producing unfavorable conditions in the host.

All that we have been saying emphasizes the need for a well-planned coordinated attack on the problems, and it is our belief that if such an undertaking be projected, say on a five year basis, the results would well repay the effort and might be conclusive. Such a plan would not interfere with the present investigations of Mr. Horace Dean, but would supplement them.

Additional information is submitted in the assumpanying addenda.

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ADDENDA

The Control of Cotton-Wilt by the Use of Organic Fertilizers

In a recent article concerning the means by which the cotton-wilt fungus, Fusarium vasinfectum, induces wilting (Jounr. Agr. Res., v. 33, pp. 1143-1162, 1926), the writer called attention to the fact that in a medium containing inorganic nitrogen the fungus produces substances that are deleterious to cotton. On the other hand, when organic nitrogen was used in the medium, no toxic effects were obtained.

In view of these findings, attention is now directed to the possibility of controlling wilt by the use of organic fertilizer, either in the form of barnyard manure or of some green manure, preferably some nematode-resistent legume. As the parasite causing wilt is a soil inhabitant, there is considerable possibility that its metabolic products in the soil may or may not exercise a deleterious effect on the roots, depending upon the chemicals present in the soil.

Cotton-wilt is much more restricted in its range and prevalence on different kinds of soil than certain other vascular diseases caused by species of Fusarium, as, for example, tomate wilt or stem rot of sweet potatoes. Barring the presence of nematodes, if a grower reports that he has considerable cotton-wilt, it can reasonably be predicted that his soil is rather poor or worn out, lacking particularly in organic matter. If nematodes are present, then the use of organic matter in such soil will not remove the possibility of wilt development, although it may partially alleviate the lesses that might be incurred by stimulating thatgrowth of the plant. Thus, as with wilt-resistant varieties, the presence of nematodes interferes with the ability of the plant to ward off infection.

To explain these phenomena, the following theory is at present held by the writer. Fusarium vasinfectum is a wound parasite and invades only after some injury has occurred to the roots. This injury may be caused by various agents, including diverse microorganisms, nematodes or other soil—inhabiting metazos, or by chemicals. Maving once gained entrance into the vascular system of the root, it lives a semi-parasitic existence within the water-conducting tubes, confining itself for a large part to a non-living meterial within the dead vessels. Only after the living tissues are killed or greatly meakened in advance of mycelial invasion will the fungus grow and fructify in these parts. This theory is in part borne out by the fact that no amount of inoculum applied to the top of a plant will induce infection on living parts.

Because of the importance of cotton-wilt, attention is directed in this preliminary note to the possibility of its control by the use of organic fertilizers. Orton's findings (U.S.Dept.Agri.Farmers' Bul. 533, 1910), which have doubtless acted as a deterrent in the use of organic fertilizers for the control of wilt, are based on very little experimental data, and his

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results are contradicted by the work of Fulton (La. Agr. Exp. Sta. Bul. 96, 1907). The writer has some data which seem to confirm Fulton's work. (R.R. Rosen, Agr. Exp. Sta., Univ. of Arkansas, in Science, June 24, 1927.)

Soil Temperatures and Fusarium Wilt Disease

Fusarium species. Gilman's (4) observations, at first in Wisconsin fields and later continued in greenhouse experiments with the soil organism Fusarium conglutinans, seem to show conclusively that its ability to induce the cabbage yellows disease is conditioned upon a soil temperature of 17° or above, and that it is powerless as a parasite at lower soil temperatures.

Tisdale (5), working in our greenhouses, has since shown similar limitations to hold for another Fusarium root disease, flax wilt, (Fusarium lini). Thus, in his experiments using badly infected soil, the flax developed normally when the soil temperature was held continuously below 15° C., but if the temperature rose for even one day above 16° C., infection occurred and the wilt followed.

Orton, discussing the potato plant in its relation to disease, has pointed out (6, 7) that the Fusarium wilt of the potato has a southern range as compared with the similar Verticillium wilt of the northern regions. Haskell of Cornell University (in correspondence) states that his studies lead him to the conclusion that "soil temperature is the most important limiting factor in the development of Fusarium wilt of potato in New York State."

Lin (8), in connection with his physiological studies of two strains of Fusarium in their causal relation to tuber rot and vine wilt of potato, finds that F. oxysporum has a higher optimum temperature than F. trichethocioides and concludes that this may explain the fact that the first is the cause of field wilt under warm soil conditions, whereas the latter develops as a tuber rot under cooler storage temperatures.

Humphrey (9), working in the State of Washington, concluded that the occurrence of the Fusarium tomato blight of the Facific Northwest (Fusarium orthoceros and F. oxysporum) is conditioned upon high temperatures. While he recognizes as possible factors air temperature and winds in relation to transpiration, he concludes that it is when the soil temperature rises too near the optimum for the parasite that the disease results. He finds that these tomato parasites show infective powers at 18° C. (65°F.) and that their virulence increases with rise of temperature to their optimum 30°C. (86°F.). The writer (10) and Gifford (11) have recorded the association in Vermont of the Fusarium damping-off in coniferous seedlings with high soil temperatures.

These things, together with the prevalence of Fusarium root diseases in the southern states, seem to justify Wollenweber's generalization (12) that the root-invading Fusariums are warm soil organisms. (L.R.Jones, Univ. of Wisc., Madison, Wisc., in The Plant World, vol. 20, No. 8, August, 1917).

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Soil Temperatures and Fuserium Wilt Disease

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Soil Acidity and Plant Growth

TOTAL After all, how often do we really determine the physiologically effective pH of a soil solution? Nearly all pH values reported so far have been determined on soil suspensions. In some investigations it has been found that within wide limits, the proportion of water to soil had but little influence on the reaction of acid soils. As the investigations are extended to include an increasing number of soils, instances are being reported in which changing the proportion of water does make an appreciable difference in the reaction of the suspension. Probably this should be expected in view of our present knowledge of soil solutions and soil extracts. The solid phase would be in equilibrium with a different solution for each proportion of water, which might result in an alteration in the amount of acid substances dissolved or in the extent of their hydrolysis. But suppose, instead of using a soil suspension, that we determine the pH of a solution displaced from a soil at a desired moisture content, are we then in a position to state that the reaction as determined is of exact physiological significance? Clearly, we are faced with the same difficulties of interpretation that have already been described with reference to the general composition of the soil solution. (D. R. Hoagland in Hilgardia, vol. 1, No. 11, November, 1925.) unce is of long semaling and since me-collect mild notify alone) invertibly reals

Securing Disease Resistance by Breeding and Selection

Let us very briefly note some of the more important accomplishments in the production of disease-resistant plants. W. A. Orton, by selection, succeeded in producing a number of varieties of cotton resistant to wilt (Fusarium vasinfectum) and, by crossing the citrus with the water-melon, he produced a commercial water-melon resistant to wilt caused by a soil Fusarium (2). It is interesting to know that this water-melon did not prove to be resistant when grown on the Pacific coast. Bolley, by selection, has produced strains of flax resistant to wilt (Fusarium lini). J. D. Norton, by hybridization, has furnished asparagus growers with varieties resistant to rust, such as Martha and Mary Washington (3). L. R. Jones has supplied Wisconsin cabbage growers with commercial varieties of cabbages resistant to yellows, caused by the fungus Fusarium conglutinans. Johnson has, by hybridization and selection, produced strains of White Burley tobacco showing marked resistance to root rot caused by Thielavia basicola. The immunity of many commercial varieties of potatces to canker or wart disease has been demonstrated in Germany, Holland, England and America, and affords a striking instance of practical control by substitution of immune for susceptible varieties. (J.E. Howitt, Prof. of Botany, Ont. Agr. Col., Guelph, Ont., in Seventh Annual Report of the Quebec Society for the Protection of Plants, 1923-1924).

Acid Soils

The only conclusion possible at the present time is that there are probably several kinds of acidity and many degrees of the same acidity as far as toxic influences are concerned. Moreover, dissimilar plants seem to be affected differently by the same acidity, while the same plants respond diversely at different times. Hoagland (Hoagland, D.R., Relation of the Concentration

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and Reaction of the Nutrient Medium to the Growth and Adsorption of the Plant; Journ. Agr. Res., Vol. XVIII, No. 2, pp. 73-117, 1919) and others (Gillespie, L. J., The Reaction of the Soil and Measurements of Hydrogen ion Concentration; Journ. Wash. Acad. Sci., Vol. 6, No. 1, pp. 7-16, 1916); Sharp, L. T., and Hoagland, D. R., Acidity and Adsorption in Soils as Measured by the Hydrogen Electrode; Journ. Agr. Res., Vol. VII, No. 3, pp. 123-145, 1916); (Gillespie, L. J., and Murst, L. A., Hydrogen Concentration-Soil Type-Common Potato Scab; Soil Sci., Vol. VI,No. 5, pp. 219-236, 1916) have demonstrated that some plants grow better in a slightly acid medium, which seems to indicate that the hydrogen ion concentration less than a Ph value of 7, so often reported in so-called acid soils, is concemitant with a toxic constituent or with malnutrition and is not in itself the harmful agent. This argument, however, does not admit that the hydrogen ion is not in many cases the true explanation of the toxicity of certain acid soils, nor does it suggest that lack of nutrition may not be a serious consideration.

In the light of the explanations offered above, it is evident that the term soil acidity is inadequate to express the inorganic toxicity that accompanies a hydrogen ion concentration below Ph 7, as the condition referred to is, in many cases, not due to the hydrogen ion in detrimental concentration. Since the term is of long standing and since so-called acid soils almost invariably yield an acid reaction with litmus paper, the phrase will continue in use in spite of its misleading reference.

Why soil acidity develops. No matter what hypothesis may be considered as best explaining soil acidity, scientific and practical men are agreed that the addition of certain compounds of calcium and magnesium tend to alleviate the detrimental condition. Conversely, almost everyone is willing to admit that the most reasonable cause of its development is the loss or inactivity of certain bases. A lack of calcium seems especially prone to allow an increased hydrogen ion concentration to develop and may at the same time encourage the activity of certain toxic bases or produce malnutrition. The tendency of all soils in a humid region is, therefore, towards acidity, their condition depending on the activity of certain factors which seem to produce such a condition. The four important factors generally specified as encouraging acidity are: (1) leaching losses, (2) cropping losses, (3) absorption phenomena within the soil, and (4) fertilizer residues. (The Nature and Properties of Soils, Lyon-Buckman, pp. 550-352).

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Some Results Likely to be Secured from a Coordinated Study of Wilt Disease

- 1. Discovery of the factor or factors in certain "safe" soils such as those of Quirigua in Guatemala and in the Ulua district in Honduras where there is freedom from wilt disease, although Ph values are not different from other soils where disease is prevalent.
- 2. Application of knowledge gained under (1) to prolonging profitable banana production on "safe" soils and making safe considerable areas of marginal soils now considered ussafe as shown by Ph values.
- 3. Discovery of methods for the rehabilitation of lands abandoned as a result of wilt.
- 4. Discovery of new facts relative to <u>Pusarium cubense</u>, especially conditions inducing pathogenicity and ability to identify in the soil and host the pathogenic form or forms of the fungus. (B. T. Galloway)

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